D. A Review of Dating Methods now used in Japan

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In the last decade or so, marked progress has been made in the geological study of the Pleistocene formation. During the Pleistocene epoch many volcanoes in the Japanese islands were so active that a vast amount of volcanic ash covered a large part of the islands. In 1949 preceramic stone implements were found for the first time in such a volcanic ash layer, and since then many similar discoveries have been reported from various regions of Japan. Owing partly to these discoveries, the Pleistocene formation drew the attention of geologists and geomorphologists, and in 1953 a research group was organized by these specialists and included archæologists. This group has carried out intensive studies on the volcanic ash layers especially in central Japan, and successfully established their stratigraphy which covers the whole range of the Quaternary period. The term 'Tephrochronology' (*tephro* means volcanic ash) was given to this sort of chronology.

In Hokkaido lying north of the main island of Japan, many volcanoes erupted in the Holocene epoch, and the eruptive materials from these volcanoes formed layers in the superficial subsoil. Shinobu Yamada, a pedologist, studied the stratigraphy of these layers and determined the absolute date of each layer by studying old records on volcanic eruptions, the estimated accumulation rate of peat formation, and so on. He classified fifty-four different layers derived from twelve volcanoes in the southern part of Hokkaido. The date of these layers goes back to more than 5,000 years. The stratigraphy thus established serves to date the potsherds and other remains which are often found in those layers.

Even before these intensive geological or pedological studies were done, the change in ancient coast line had long been noticed by archæologists in relation to the location of prehistoric shell-mounds around Tokyo Bay. The first attempt at dating a prehistoric site in Japan was performed by John Miln about 80 years ago. Based on the accumulation rate of alluvial soil, Miln obtained the age of 3,000 years for a shell-mound located at the ancient coast. In the 1930's members of the Ohyama Institute of Prehistory carried out a systematic study to compare the chronological sequence of pottery types with the regression of the ancient coast line. It is evident from the distribution of shell-mounds that the Bay of Tokyo once intruded into the alluvial plain as far as 80 km. from the present coast line. This seems to have been the case about 5,000 years ago. The sea-level of those times must have been 5 metres or so higher than the present. Assuming the shell-mounds of sea shells were made near the coast line and those of fresh water shells were made after the coast line had receded, the pottery types found in these shell-mounds were consistently connected with the gradual regression of the ancient shore line.

The pollen sequence in the peat formation in Japan has become clear rather recently. Jun Nakamura, Shoichi Hori and Matsuo Tsukada analysed the peat from bogs in central Japan and obtained similar results with respect to the tendency of

the forest succession or climatic change. In the peat of these bogs are often found tephro layers some of which are datable by the old records of volcanic eruptions. From these layers of known age Hori computed the growth rate of peat to estimate the absolute dates of individual layers; he concluded that it was cold about 10,000 years ago, then it became warmer until 6,000 years and again cold from 3,000 to 4,000 years, thereafter it became warm. Generally speaking, this tendency matches the postglacial climatic change obtained in Europe as well as in America.

As to the climatic change of more recent times, some results have been obtained from tree-ring analyses. In 1935 Jun Shida measured the annual rings of a 1,000 year old cypress tree from Mt. Alieshan in Formosa. Takeo Yamamoto compared this tree-growth curve with the advance and retreat of the Alpine glaciers during the 13th to the 19th centuries. He found a notable correlation between them. The curve was also compared by Hideo Nishioka to that a of cypress tree, 800 years old, from central Japan. Nishioka found a 700-year cycle of climatic change which was in accord with the descriptions of climatic conditions in old documents. Recently Jiro Kohara measured the tree-rings of the central column of the pagoda of Hōryū-ji temple, the oldest monument in Japan built in the 7th century. These growth-curves may be of use for the application of dendrochronology in Japan. However, no attempt of this kind has yet been carried out.

Chemical analysis of bones has also been made to determine their age. Hiroshi Hamaguchi measured the fluorine content of human bones from prehistoric shell-mounds as well as protohistoric burial mounds. The result appears to the that the ratio of fluorine to phosphorus content is greater with time. Recently some human bones have been found in a Pleistocene formation in central Japan, and the fluorine test was applied to them by Giichi Tanabe. The result suggests that these human bones were contemporary with the animal bones presumably of the Upper Pleistocene. Tanabe also determined specific gravity, content of organic matter, ratio of calcium to phosporus contents and iodine number of bone fat on bones from shell-mounds and burials. These measurements, however, were rather negative with regard to the correlation to the elapsed time. Tamia Asari measured the strontium content of human bones and reported that it was richer in bones from protohistoric burial mounds than in those from prehistoric shell-mounds.

Besides these changes in the chemical constituents of bones, some change in course of time may have taken place in their crystal structure. The inorganic constituent of bones and teeth is apatite and as the crystal structure of minerals is analyzed by means of X-ray diffraction pattern, in 1946 I took the X-rays of bones of various ages by the powder method. But the difference of pattern could hardly be recognized among them. In 1959, I tried it again by a highly sensitive X-ray diffractometer at the University of Tokyo. The diffraction patterns of bones and teeth in various ages from the recent to the Pleistocene epoch suggested a tendency that the older the material the sharper its diffraction pattern. Bone apatite seems to approach natural apatite as time goes on. A study is in progress to make use of this in dating.

Mention should be made of the present status of radiocarbon dating in Japan. There are three centres for radiocarbon assay, the Scientific Research Institute,

the University of Tokyo, and Gakushuin University; the first two are in the stage of preliminary experiment and only the last is in operation.

Other studies directly or indirectly relating to the dating problem are also being pursued. For instance, Hisashi Suzuki studied the change in the form of clam-shells through the ages. Nakao Doki made an investigation of the number of radial costae of Anadara shells from prehistoric shell-mounds, and Shohei Kokawa reported the change in the form of *Menyanthes* seeds during the Quaternary period. Based upon an empirical principle that the equilibrium of carbon, hydrogen and oxygen contents of coal changes in course of time, Kazue Watanabe devised a dating method which was applied to Tertiary coal layers.

In conclusion, some dating methods effective elsewhere have rarely been applied successfully in Japan; on the other hand conditions peculiar to Japan, for instance, the volcanic activities, have favoured the development of some specific dating methods in Japan.

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